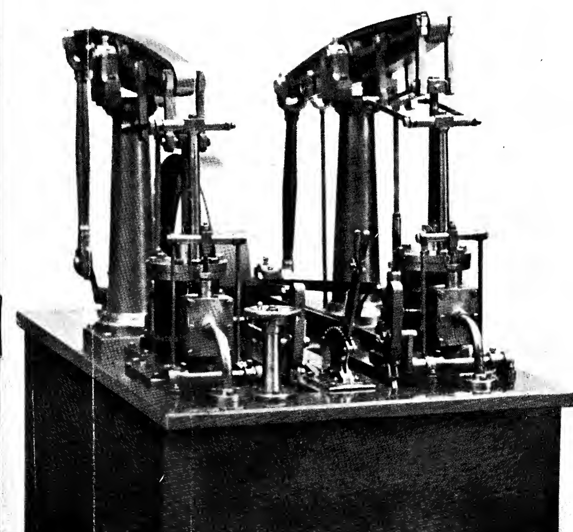
THE MODEL ENGINEER

Vol. 98 No. 2457 THURSDAY JUNE 24 1948 9d.



The MODEL ENGINEER

PERCIVAL MARSHALL & CO. LTD., 23, GREAT QUEEN ST., LONDON, W.C.2

24TH JUNE 1948 VOL. 98 NO. 2457

SMOKE RINGS

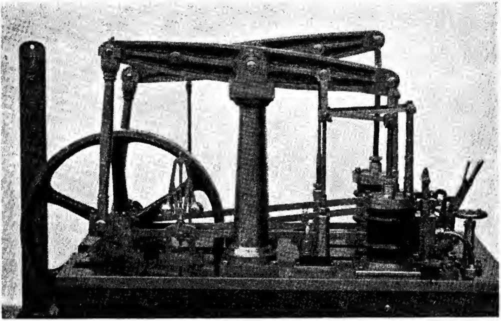
Still More Exhibition Awards !

● I AM happy to announce this week still more prizes to be awarded for entries in the Competition Section of this year's MODEL ENGINEER Exhibition. THE MODEL ENGINEER and its associate journals *The Model Railway News, The Model Car News, Model Ships and Power Boats* and *Model Aircraft* are each awarding prizes of vouchers valued at five guineas for the purchase of equipment and goods from any of the trade exhibitors having a stand at the exhibition. The specific merit for which these awards are to be made has not yet been finally decided, but they will, of course, be for the type of model for which the journals cater. Further details will be published as soon as a decision has been reached. A handsome silver cup, to be engraved with the name of the winner, has been donated by Roox Products of Alton, Hants., for the best cine projector following the general design of the "M.E." cine projector designed by "Kinemette." Improvements in the original design will enhance the designers chances of the award. A further award just received comprises a set of castings and working drawings, for the construction of a 0-in. to $\frac{3}{8}$ in. capacity sensitive drilling machine. This has been donated by The Perfecto Engineering Company of Leicester.—P.D.

The Model Car Association

● MR. G. E. JACKSON, 1, Lime Grove, Chaddesden, near Derby, the secretary of this newly-formed association, tells me that whilst the leading clubs have been quick to send in their applications for affiliation, the smaller clubs have been somewhat slow in responding. Mr. Jackson gives it as his opinion that this is not because the smaller clubs fail to recognise the advantages of affiliation, but because they hold their meetings less frequently, and decisions of this nature and the nomination of committee men cannot be carried through so quickly. As materials and components become more readily available, the sport of model car racing is entering upon a phase of rapid expansion and development. Hardly a week passes without news reaching us of the formation of a new club or of a model car section to an existing club, or of a track under construction, or of racing facilities becoming available. Given strong support for the association, I foresee the time when it will be possible for teams from America and the continent to visit this country, and teams from this country will go overseas to compete in international competitions, but first we must organise on a national basis, and this can only be done by supporting a national body capable of handling the organising and financing

of such events. The future development of the model car movement will be determined by the enthusiasm of its followers; whether that development be small or great will depend on the extent to which they are prepared to back their enthusiasm by action. A strong national movement holds many pleasant prospects and possibilities, but the inflexible rule which makes it impossible to get something for nothing applies here, too. Like all good things, including national prosperity, if we want them, we must work for them.—P.D.



Side view of Mr. Leslie Scott's model coupled beam engines. (See other view on cover of this issue)

Our Cover Picture

● THE VERY unusual model of two beam engines coupled at 90 deg. was built by Mr. D. Leslie Scott of Dunedin, New Zealand. Mr. Scott is evidently a model engineer who loves engines for the fascination of their complicated movements in action. He writes :—" My idea at the outset was to construct a slow working model with plenty of moving parts. In coupling two engines at 90 deg., the result has at least fulfilled my objective. The model claims the attention of even those not mechanically minded, as being different from a complicated model where the moving parts are hidden." Mr. Scott goes on to say that his vocation is in no way connected with light engineering, and I am sure readers will agree that this fact adds greatly to the credit due to the maker of this excellent piece of craftsmanship.
—P.D.

" Isis "

● WHEN I was a small boy, eleven years of age, I had the thrill of riding on a locomotive for the first time in my life. I rode from Midgham to Reading on the G.W.R., and the engine was a fine old double-framed 2-4-0, No. 73, *Isis*. This engine was scrapped in 1918, and she was then added to the list of those of which I intend to build models, if and when I can ever find the time! But, in the case of *Isis*, I have had the pleasure of watching the gradual growth of a very lovely replica, though it is to the very unusual scale of $\frac{13}{16}$ in. to a foot. It is the work of Mr. J. Refoy, of Windsor, and it has progressed far enough to be tried in steam on the bench. If nothing occurs to prevent it, the engine will be seen at the forthcoming MODEL ENGINEER Exhibition, and I am hoping to obtain some photographs of it for publication in THE MODEL ENGINEER. Owing to the curious scale of $\frac{13}{16}$ in. to the foot, the track gauge required is $4\frac{13}{16}$ in. This, however, was requested by the engine's eventual owner; but it has meant that all castings had to be obtained from specially-made patterns, adding much to the time and expense of construction. Nevertheless, I am glad to see *Isis* again!—J.N.M.

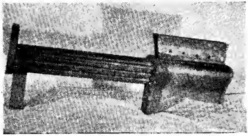
The "M.E." Index

● ANOTHER VOLUME of THE MODEL ENGINEER has now been completed and we repeat our offer to supply subscribers and regular readers with the index for Volume 98, if they will send us a stamped addressed envelope (1d.) of sufficient size to take a copy of the journal flat. The index will not be printed until we know how many copies are required to fill the demand, but readers are requested to make early application to the Sales Manager, THE MODEL ENGINEER, 23, Great Queen Street, London, W.C.2.—W.H.E.

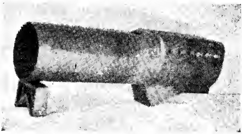
The Story of "Centaur"

by J. I. Austen-Walton

I HAVE delayed the writing of the story of *Centaur* until she had been given an opportunity of stretching her legs a bit on the track. This opportunity came soon after last year's "Model Engineer" Exhibition, when the Malden and District Society of Model Engineers invited me down to the Thames Ditton circuit on the occasion of their gala day on September 7th, last. This would appear to be giving the end of the story before the beginning, but I feel that it might be worth knowing what sort of an engine she has turned out to be, compared with what she appeared to be at the exhibition.



The tubes and firebox



The boiler shell

It was obvious that some kind of try-out should be made before the actual day, and this was arranged with the Malden Society, and the engine was steamed up in a very short time. Sitting behind the engine and reaching for the regulator was, perhaps, one of the worst moments of my life. But away she went with a roar that was most impressive—much too impressive in fact! I knew that all was not well. Too much steam was being used. A hundred and one thoughts raced through my mind in trying to probe the mystery of that almost unbroken blast from the chimney. She ran several circuits maintaining steam unusually well, but the water consumption confirmed the tale of wasted power. I felt disappointed and a little downcast—the great moment had turned out to be rather a dark cloud.

That same evening, two very worthy members of the Malden Society came back with me for a quiet brains trust session. Was it pistons? Was it piston valves? Eventually, the pistons themselves were suspected and these being the most accessible in the case of the two outside cylinders, the front covers were removed and the pistons drawn out.

Centaur had pistons modelled on the original "Corliss" type marine engines, with one wide central stepped piston ring, making up nearly the full width of the piston itself—in this case ½ in. wide—and made in correct eccentric form of stainless steel. The bores of the manganese bronze cylinders were perfect and undamaged, and the rings fitted well. They had retained their spring and showed a good seating "witness" all round.

Frankly, I was baffled. My thoughts turned to the re-making of the entire piston-valve gear, and while I was so meditating I re-entered one of the pistons and its ring into the cylinder. When it was halfway in I noticed that the horizontal joints of the steps were a little way apart. Quite correct this, I thought, for there must be room for the expansion of the ring. Then, in a flash, I realised how one very important, but simple, point had been overlooked. The steam would pass through one slot, get under the ring, and out of the other slot, because the central bar would not complete the seal.

Out came the pistons, the rings were put in the museum of failures, and two new square-sectioned graphited cord rings were substituted with a solid floating ring in between to make up for the difference in total width. It was then very late and I had to go to town on the next day, so the job of replacing the centre cylinder piston had to be left. At least she would be two-thirds better off and would have to take a chance on Sunday, hoping for the best.

On the gala day, *Centaur* ran and hauled many passengers. As I had expected, the performance was just that two-thirds better and the water-pump was able to keep pace with the boiler's needs. As a general precaution, the working pressure was kept to 60 lb. only and, on this pressure, the engine was able to haul sixteen adult passengers without much trouble. Other small faults were then showing up, but they were trivial things compared with the first trouble and were easily remediable. When the season ended, *Centaur* was stripped down and all the faults put right. During the coming season, I hope to demonstrate her real hauling powers.

All this brings me to the original ideas that led to the building of *Centaur*, the kind of performance and appearance that fired me with that great enthusiasm that only a loco-building man can appreciate.

Now I can get down to the real beginning of

things; why a "5 XP" was chosen as a type, and how and when she began to take shape. *Centaur* was laid down during the war when materials were not too easily procurable. One could get a lot of some materials and often none at all of the particular material required for a certain job; everyone was too busy to take the needs of a model engineer too seriously, so it was a case of keeping the eyes open when going about the country. About that time I was travelling quite frequently to the North, with Euston as the departure terminus and Manchester or Stoke the destination. On one of my early journeys, I got to Euston with more than usual time to spare, which meant hanging about the forward station ramp to see the engine come in and couple up. Presently, *Silver Jubilee* creaked and groaned over the sharp-radius curves of the points and came to rest. She was wearing her best war grime and soot, but still I liked the look of her. She wasn't exactly new to me, but this time I took in much more detail and began to think of her in terms of building. Then the still nebulous thoughts became a little more settled as I noticed the way she tackled the Camden Bank and, by the time I reached Stoke, my mind was made up.

The next step was a letter to the Publicity Department at Euston, asking for drawings, and I must say that I was given excellent service and help in that direction. In due course the most important prints arrived, with charges that were very moderate indeed. I was promised other drawings from time to time, as other model engineers also had needs in that direction.

Now works drawings are all very well in their way but, especially if time is of any importance, they can be the most bewildering things. I found that hours of careful study were needed when some small detail had to be picked out. Quite automatically, my drawing board came out and "extracts" were made and dimensioned. This procedure was later enlarged upon in the laying out of quite big drawings showing the valve-gear with the scale amended to give scale working. Items such as the pistons had to be thickened up and castings had to be modified to make them "draw" without a multiplicity of elaborate core boxes.

The boiler was another item in need of sweeping revision; several drawings were made and different tube arrangements tried out and calculated. The boiler was, in fact, headache No. 1; so, being as unorthodox as it is possible to be, I started to build the boiler before the engine. I knew, by then, the width between the frames and the length of the barrel and firebox, so materials were calculated and a start made.

The Boiler

Having finally settled all the points in connection with the boiler design, I bought ⅛-in. and 5/32-in. sheet copper, 7/16 in. × 18-gauge and 15/16 in. × 18-gauge copper tube. About this time 20-gauge tubing was not obtainable anywhere, nor at any price, so I just had to make do. From the very beginning the loco experts were calling in to see me, and shaking their heads gravely at the mention of 18-gauge for boiler tubes. "She'll never steam well," they all said. I began to wonder myself.

Formers

Next to the raw materials came the formers, and on these I really spread myself. ½-in. mild-steel plate was roughed out and then finished exactly to size, special care being taken to see that all formers were symmetrical. I had seen so many boilers with firebox corners having visibly different radii on the sides and tops and, in some cases, very obvious signs of the sheet-copper having been beaten out over rough plates. Copper-sheet of ⅛ in. thickness, and over, may quite easily take on the pattern of the former plate edge, especially when a hard and heavy hammer is used. All the formers were of the usual pattern, with the exception of the throat-plate. This called for special care. The throat-plate of a "5 XP" can be a complicated job for a beginner, and to someone with experience it is still a troublesome job. I was anxious to avoid the use of a separate inside band where throat-plate and boiler barrel meet, and I devised a method entailing two operations that appeared to fill the bill without over-complication.

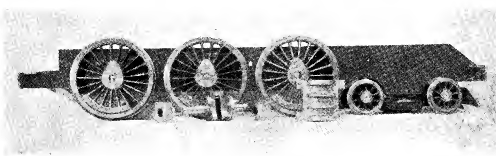
First of all, I made the usual former having the outer firebox wrapper outline and, at the exact boiler barrel centre-line, I drilled a ⅜-in. hole. This same former was then cut across its width at the point where the throat-plate sweeps back to avoid various things inside the frames, and the piece cut off was welded on again at the set-back angle. Next, a large hole was roughed out in another piece of plate, bored out the same size as the inside diameter of the boiler barrel and radiused over one edge. By dint of careful roughing, the solid blank removed was also turned down 5/16 in. smaller than the diameter of the hole out of which it came, and, whilst set up, a ⅜-in. hole drilled through its centre.

The method of using these pieces was as follows: The copper throat-plate blank was made and a hole cut in its centre—again boiler barrel centre, but 1 in. smaller in diameter. The blank was annealed and clamped on to the plate with the large hole in it, arranging it so that the hole in the blank centralised with the hole in the plate. The overhanging copper was then gently beaten down all round inside the hole, forming a collar inside the former. When this was completed, the solid disc could then be pressed into the middle of the former with the blank still in place. This entire assembly was bolted through the drilled ⅜-in. hole in the middle on to the firebox shaped former and, this time, the overhanging flange of copper round the outside edge was beaten back over the former the opposite way and continued down, taking the swept-back portion and flange in one operation. It was still possible to remove the blank from time to time for annealing—I believe twelve to fourteen times in this case—and to reassemble without losing its essential location. The resulting part presented a neatly-formed round collar facing forwards, and a firebox shaped flange facing backwards, all in one piece.

The formers for the tapered boiler barrel and the inner and outer firebox wrappers were made from large pieces of elm, sawn and planed up

with the same care and regard for symmetry. The rolling up of the barrel was sheer hard work, but presented no special difficulties in other respects, and the lengthwise join was completed by using a wide, flat strip of self material, riveted and brazed inside. Very soon the barrel and throat-plate, the tubes, firebox tube-plate, inner wrapper and girder-section crown-stays were all brazed together, not forgetting the firehole door ring in the inner member only, and I began to think of staying.

hole right through. The main trunk steam-pipe was also brazed into the tube-plate and extended back to a large winged elbow facing upwards and carrying two stainless steel studs which came up to the level of the dome-ring top flange. The regulator itself, embodying a disc-on-a-face type of control, was made on to a flange matching the dome-ring flange and extending down below it, with a steam outlet coinciding with the winged elbow on which it also sat. The two long studs clamped the



Parts of the chassis

regulator unit to the elbow and completed the seal. A third plain disc capped the lot, all three pieces being drilled for studs. The regulator handle operates the disc through a long, stainless-steel rod, squared at its forward end, which mates up with the driven disc. At any time, I can remove the top cap and see the regulator moving (not in steam, of course) and, if things do not appear to be right, a further two nuts will release the entire regulator as a unit.

I have always hated seeing that ghastly row of massive stay-heads on the side of the firebox, and I set about making a simple tool to avoid this trouble. Two odd pieces of mild-steel bar, about $1\frac{1}{4}$ in. diameter $\times$ 1 in. were taken. The first was chucked, faced, centred and drilled through 5/16 in. Then a round-nosed boring-tool was used to produce a cavity $\frac{1}{2}$ in. deep by $\frac{3}{4}$ in. diameter. The second piece was also chucked, faced and drilled through 5/16 in., whilst the outside was turned down to $\frac{1}{2}$ in. diameter for $\frac{3}{8}$ in., the front edge of the turned portion being radiused to about equal the radius of the boring-tool used. The resultant parts fitted into each other with $\frac{1}{8}$ in. space all round. When the outer firebox wrapper had been drilled with a row of 5/16-in. holes where the stays were to emerge and the whole thing annealed, the steel cup was placed inside the wrapper and the steel plug outside the wrapper, both well greased, and a 5/16-in. high-tensile bolt passed through the lot. Tightening the bolt produced, one by one, a series of neat pockets in the wrapper and it was possible to snug down the stay-bolt heads to a flush exterior. This series of pockets also strengthened the wrapper by giving it stiffness. The rest of the boiler was orthodox in assembly procedure, and "L.B.S.C.'s" advice on this subject is probably the soundest ever given.

But there were details still to be added and the regulator was one with which I felt I should explore new ground. A regulator is a moving, mechanical part and I felt that, in time perhaps, scale and other foreign matter might upset the working of this only-too-well-hidden part. I decided to make a regulator that could be removed and replaced easily without the fear of twisting off pipes and broken-in screws. To do this, a large flanged ring was made and brazed into the boiler, giving a good $1\frac{1}{2}$-in. diameter clear

To summarise the boiler, these are the main features: 26 fire tubes, 7/16 in. diameter $\times$ 18-gauge. Two superheaters, 15/16 in. diameter $\times$ 18-gauge. Two longitudinal stays, $\frac{1}{4}$ in. diameter. 114 firebox stays, 3/16 in. diameter, brazed inside and out. Main boiler brazing in "Cuprotectic," secondary brazing in "Easy-flo." Hydraulic test 340 lb. per sq. in. (anxious moment, that!) Working pressure 150 lb. Two superheaters have block-type spearheads in stainless steel. Grate and ashpan in stainless steel.

Comparing the boiler now with "L.B.S.C.'s" "Olympiade" and making allowances for scale, there is very little difference. I'm afraid one has to get up very early to catch him out! But the finished boiler screamed out for a finished chassis, and then the work really began.

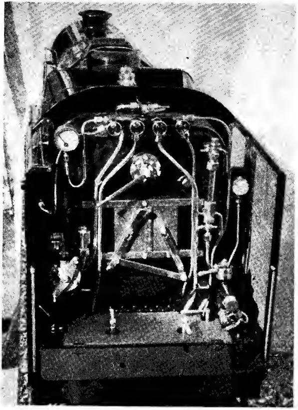
The Chassis

Before any work was done on the chassis and frames, I went to earth with a notebook, drawing board and all the information I could lay hands on. In this somewhat exotic and unsocial state, I remained until a perfectly clear picture of the exact details of *Centaur's* under-works had come into being. The term "picture," in this case, should be assumed to mean more of a specification than a mere visual impression, and for those who plan their locomotives on similar lines, these were the findings:

First, the engine was to give a good performance on the track without losing too much in the way of looks and general proportions. Inescapably tied up with this consideration came the question of details, what to have and what to leave out as not being absolutely necessary. Dealing with the "haves," these were the items chosen: Piston-valves throughout; steam brakes on engine and tender; full working leaf springs right through; ball-races and friction-defeating devices wherever possible; stainless steel for every item in steel where suitable material could be obtained and, lastly, though not strictly a detail of construction, a good driving and working position. That would describe the initial findings, although many more additions were discovered and added as time went on.

And now the "have nots," which were of this order: No sanding-gear. And here I must digress for a moment to amplify this omission. Full working sanding-gear is quite easily made, but there is no satisfactory substitute for sand giving the necessary grip without the danger of abrasive material getting into the works. The idea of blasting any kind of powder, gritty or otherwise, over the valve-gear and round about, horrified me. A further realisation clinched the matter, and that lay in the cleaning and general access department. Getting round the wheels with rag after a track run, when most of the track rust has been gathered to the wheel-treads is perhaps my *bête noir*, and the inclusion of the necessary extra pipes would have made cleaning operations unusually tricky. So this omission stood and my conscience was at ease.

But to return, the next omission was centred round the backhead, and scale backhead fittings largely "went by the board." I wanted a water-gauge that I could see (without moving the cab roof), fire-hole doors that would open and close without taking up too much room and the general disposition of controls without regard to their correct positions. The omission, therefore, took the form of setting out all the taps, blobs and handles with accessibility as the first and almost only consideration.



A view of the controls

The next "have not" dwelt, not so much upon mechanical lubricators, as upon the methods of operation, unfortunately, all too often seen in the form of external levers, arms and ratchets.

A further "have not" was a working water pick-up on the tender, for I felt that it would be quite useless to me. There are a few lucky track-owning enthusiasts who have fitted up the necessary gear, but I am not in that fortunate position and have to depend on facilities provided in various places, and have yet to see a track fitted with water-troughs.

The final "have not" lay in the use of hexagon bolts and nuts instead of countersunk and cheese-head screws. I abhor the use of these screws, even when they cannot be seen, and I challenge anyone to point out a single screw either inside or outside the engine. Strange to say, the use of "Allen" type screws does not offend me in the same way, provided always that they are used with discretion; their great strength and ability to be tightened well up when in obscure places has solved many a knotty problem for me and I have yet to hear of one stripping or twisting off.

Eventually, there were drawings made covering the work for some time ahead, and when some perfectly flat steel 5/32 in. thick came to hand, the frames, riveted together and marked out in the usual way, soon came into being. This was the easy part, and most loco builders pass this stage with a flourish and flush of triumph. I was the same. Simply brimming over with keenness and energy, and having perfectly ordinary horn-blocks cast from my own pattern, I proceeded to profile-mill them all over! Of course, when finished they looked delightful.

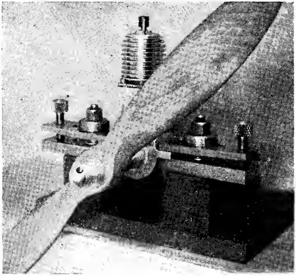
(To be continued)

PETROL ENGINE TOPICS

Testing Small I.C. Engines

by Edgar T. Westbury

THE study of engine design in general, and the development of high performance engines in particular, can only be carried on systematically and progressively if means are available for observation of the engines under running conditions, and preferably in conjunction with actual measurement of torque and speed. This fact is one which I have repeatedly stressed in the past, yet after many years of intensive development of small i.c. engines, it is still the exception, rather than the rule, to find users of these engines who are prepared to go to the trouble of testing them properly.



An engine mounted on the simple universal test stand

Constructors of these engines are often so happy in the enjoyment of the first fruits of their labours—the revelation that the engine they have built actually runs!—that they regard this as the culmination of the job they set out to do, and are not inclined readily to accept the idea that work on the engine is by no means completed. In many cases, they rush off to build a boat hull, an aeroplane or a car chassis as quickly as possible, in the hope of tasting that success which seems to be "only just round the corner."

This experience is quite natural and understandable—far be it from me to deny it!—but only too often it leads to disillusionment, and the constructor may find, after much time and effort has been spent in the pursuit of an objective which persists in eluding his grasp, that the engine is not as good as he thought it was, or more likely, that he has not yet learned how to get the best results from it.

So many readers are interested nowadays in the attainment of high performance with small engines that I consider the time is highly opportune to give some further practical hints on engine testing, although they are largely a reiteration of what I have said many times in the past, and it may be necessary to apologise to advanced readers for raking up ancient history. I am, however, quite certain that this subject is one of the most neglected by engine enthusiasts, and that more careful attention in this respect will eliminate many of the ignominious failures and disappointments which occur at practically every meeting at the pond, aerodrome or race track.

To a good many engine users, a test consists of nothing more elaborate than screwing an engine down to the bench, starting it up and twiddling the controls to eliminate spluttering and misfiring, and to get the engine running as happily as possible, judging mainly by ear alone. True enough, this does constitute a test of a sort, and it is, by no means, without practical value, especially if the engine is run under a constant load, and a careful check is made of the position of all adjustments when the best results are obtained. Constant practice will attune the ear to detect any minor irregularity in running, or lack of "form" in the engine, and assist very considerably in getting to know one's engine properly, a most valuable factor in success.

But rough-and-ready tests of this nature have very definite limitations, especially when no attempt is made to measure speed or torque. The most futile "test" of all is when the engine is run without load, because the effect of adjustments made under such circumstances is practically meaningless, quite apart from the fact that high r.p.m. at no load has no significance, except that a really good engine opened up "flat" in this way will probably blow itself up! Needless to say, this sort of evidence of the engine's quality could hardly be very satisfying.

Neither is there any very great virtue in a "snap" test in which the engine is opened up for a few seconds against an indeterminate, and probably variable, load applied by hand through a friction pad. A fairly prolonged test, with absolutely steady load and substantially constant speed, is required to show true engine form, and any engine which will not provide this, or which one dare not run for any length of time for fear

of wearing out or mechanical breakdown, can hardly be regarded as satisfactory from the aspect either of efficiency or reliability. As I have often said, soundly-built engines, like good dogs, revel in plenty of exercise, and are certainly not harmed by running for 10 or 15 minutes or so at a stretch, provided that they are kept reasonably cooled and lubricated.

A Simple Test Stand

The commonest type of small i.c. engine used at present is that normally fitted with an airscrew for model aircraft propulsion, and of all types, this is the simplest to test, because an airscrew naturally produces a load which is roughly proportional to the speed, and this tends to keep both torque and r.p.m. fairly constant. Even engines not intended to drive an airscrew eventually may, with advantage, have one fitted for test purposes: quite apart from power testing, it is useful for running the engine during the initial bedding-in of the working parts which is so essential to its future success.

The airscrew need not be an elaborate or accurate one, since it is required to function only as fan brake. A roughly-carved wooden propeller fan, or one fashioned from sheet metal, is quite satisfactory, and the latter has the merit of being readily varied in pitch. In either case, however, it is essential that it should be in correct balance, and in the case of a metal fan, due precautions must be taken to keep the hands, or any part of the person, well away from it when running. It may be remembered that the Romans who got in the way of scythes on dear old Boadicea's chariot wheels were dreadfully "cut up" as a result! The size and pitch of the airscrew will, of course, determine the load, and the most suitable dimensions may have to be found by trial.

Assuming that it is found that a propeller of certain size and pitch seems to suit the engine fairly well, and that it is quite possible to get consistent results at definite settings of the adjustments, this will constitute the first step in arriving at an understanding of the engine's capabilities. It is now quite clear that any alteration to the engine, which enables the speed to be increased on the same load setting, is an improvement, and thus one can readily check up the effect of alterations in the compression ratio, port timing, composition of fuel, etc.

It is, however, necessary to have some means of checking engine speed more or less accurately, and this will be referred to in detail later on.

For mounting the engine on the bench, some form of temporary test bed is usually desirable, and the design of this will be governed by circumstances. It is not a big job to construct some simple foundation structure to suit any particular engine, but in cases where a number of engines of different sizes have to be tested, it is clearly desirable to have some kind of universal mounting stand available. I have seen many fearfully and wonderfully conceived devices for this purpose, but the one which I illustrate has the merit of being both simple to construct, and handy in use. It is adjustable to take engines from 10 c.c. down to the smallest size likely to be encountered (the width of bearer clamps can be adjusted from 2 in. down to $\frac{3}{8}$ in.).

The base of the stand, and the vertical supports, may be made of metal, hardwood, or plastic material (in the case illustrated, they are made of Paxolin sheet) and the supports are each secured to the post by two $\frac{3}{16}$-in. or 2-B.A. countersunk screws on the underside. One of the screws in each support is extended right through and beyond the top, to act as a holding-down stud for the bearer clamp. The latter embodies two solid steel plates, the top one of which has a knurled jack screw fitted at the tail end. Alignment of the plates is maintained by locating the point of this screw in a hole drilled partially through the lower plate. Spherically seated nuts, bearing on washers similarly recessed, are used to ensure

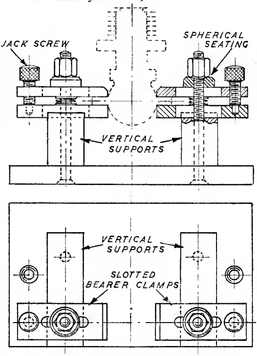


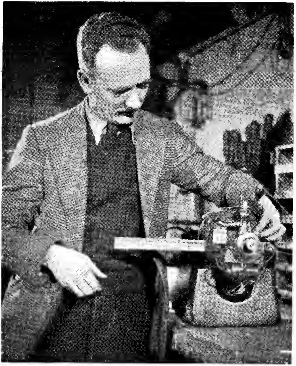
Fig. 1. Details of simple "universal" test stand for miniature i.c. engines. (Half-size)

even pressure on the bearer clamps, and the plates of the latter are held apart, when slackened off, by short springs and washers inserted between them on the holding-down studs. The clamps are held square with the supports by fitting them in grooves cut across the latter.

It may be remarked that a test stand, somewhat similar to this in function, but much more elaborate, and containing a fuel reservoir, ignition equipment and switch, is available ready-made in America, and I understand that this device is very largely used by demonstrators of commercial engines.

In this simple test stand, no provision is made for measuring engine torque, and although the comparative tests mentioned are definitely useful, they cannot provide any true indication of actual engine power. This can, however, be measured by using fan brakes or airscrews which have been

calibrated to absorb a definite amount of power at given r.p.m., but it is almost as difficult to get a reliable calibration test made as to construct a proper torque balance, and, of course, any alteration to a calibrated fan brake, such as may be produced by chipping or warping of the blades, renders it useless for accurate power measurement. In some cases, test stands have been made with provision for measuring the traction thrust of the airscrew while working, but I regard this provision as of very dubious value, because there is no definite relationship between thrust and torque which holds good generally for airscrews of different design, and static thrust is not even a true indication of the propelling efficiency of a particular power unit.



Mr. J. Cruickshank testing a 6-c.c. "Atom Minor" engine on an improvised torque reaction balance, utilising the spindle of an electric grinder

Torque Reaction Stand

It is, however, possible, and by no means difficult, to measure torque by the reaction produced against the engine test stand while it is running under load. Devices for carrying out this form of test have often been described in THE MODEL ENGINEER, but as I am always encountering querists who do not seem to understand the principles involved, I make no apology for raising the subject again here. The measurement of torque reaction constitutes the simplest method of carrying out a true power test, and it is worthy of considerable attention than it has hitherto received from engine constructors.

Briefly, it may be said that the torque reaction test is based on one of the fundamental laws of mechanics—" action and reaction are always equal and opposite "—and if an engine is producing a power thrust by turning a shaft against load resistance in one direction, an equal thrust will be exerted in the opposite direction, tending to turn the engine structure over backwards about its shaft axis. By making the engine mounting capable of rotation through a slight angle, and providing means of weighing the force exerted on it, torque reaction can be measured. Load may be applied to the engine shaft in any convenient manner, but the fan brake or airscrew is one of the simplest and most convenient methods to use for a constant load test. More elaborate methods are, however, necessary if it is desired to vary the load while the engine is running.

A convenient way of mounting an engine for a torque reaction test is to set it up on a faceplate attached to any free-running spindle: a small lathe headstock has often been used for the test stand, and it may be remembered that in some engine tests described in THE MODEL ENGINEER dated August 16th, 1945, by Mr. J. Cruickshank, the spindle of an electric grinder was used as an engine mounting. Whatever form of appliance is used, the essential thing is that the system should be in static balance before the test is commenced, and the spindle should run as freely as possible, as any friction will lead to error in measurement of the torque, and may cause considerable discrepancy when very small engines are being tested. A torque reaction mounting, which I have built specially for small engine tests, will be illustrated in the next instalment. The torque shaft runs in two large ball-races, and is equipped with a faceplate on which the bracket to carry the engine is mounted. At the tail end of the shaft a torque arm is fitted, extended equally in each direction, and fitted with sliding counterweights for adjusting static balance. The headstock, in which the bearings are mounted, is fabricated from light alloy, and embodies a limit stop to restrict the motion of the torque arm, provided with an eccentric clamping device, which enables the mounting to be held stationary when starting up and adjusting the engine. It may be recollected that in Mr. Cruickshank's test, he employed a fixed weight, which was adjusted along the length of a calibrated torque arm to balance the load. In my case, I prefer to use a torque arm of a fixed length, and to carry the weight as required, using the usual combination of a weight hanger and a spring balance, which gives greater stability than is possible with a weight alone.

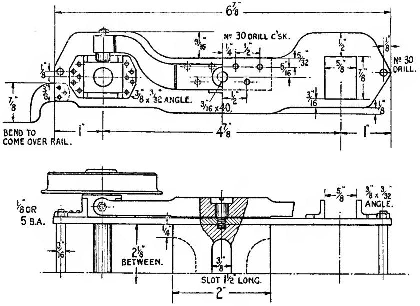
(To be continued)

A $3\frac{1}{2}$-in. Gauge L.M.S. Class 5 Loco.

by "L.B.S.C."

THE full-sized engine has a really "Bill Massive" bogie of the Adams type, with equalised axleboxes, the equalisers being of the double-plate pattern with a hefty laminated spring sandwiched between each pair. When I tell you that this spring has 13 plates 5 in. wide and $\frac{5}{8}$ in. thick, maybe you'll realise just what it has to carry. It would be quite possible to make a copy of this in $3\frac{1}{2}$-in. gauge; but to get proper flexing, the springs would have to be made on Mr. Glazebrook's system of laminated plates, and the full suspension arrangement would be a bit of a tiresome job. If we use a cast equaliser each side, with a couple of spiral springs in the centre (same as I have specified for $2\frac{1}{2}$-in. gauge engines) there is a tendency to derail on curves, as in this size the leverage between the end of the equaliser and the point where the spring takes a bearing allows the wheel to lift easily, even if very stiff springs are used. It is a significant fact that in full-size practice the bogie with independent springing for each axlebox can be found on some of the fastest engines, such as the G.W. "Kings" and the L.N.E.R. A4's, the Southern "Nelsons" and so on; and I have found on my own little railway that I can dash around my south curve with perfect safety with an engine having separately-sprung bogie axleboxes at a speed which would cause an equalised bogie to jump the road.

Bearing the above in mind, and—as always—trying to make the job of building "Doris" as easy as possible, I am specifying a bogie that looks like that on her full-sized relations, yet is in fact a compromise. The bogie frames are set closer together than the main frames, with the horn-cheeks outside, same as big sister, but a cast equaliser is used each side. This is attached to the bogie frame by a big-headed fulcrum pin, so that the equalising effect is retained, ditto the appearance of the full-sized bogie; but each end of the equaliser has a headless spring-buffer in it, bearing on the axleboxes, and giving the full effect of separate independent springing. Thus we kill two birds with one shot. The job looks all right, and works all right.



Bogie details for "Doris"

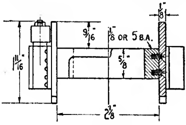
Bogie Frames

Two pieces of $\frac{1}{8}$-in. soft steel plate, 7 in. long and $1\frac{3}{4}$ in. wide, will be needed for the bogie frames. Mark out, rivet temporarily together, and drill and file to outline, same as main frames. There is nothing very special to note about the job. The holes for the tie-bars, drilled No. 30, are $\frac{1}{8}$ in. above the centre-line of the axlebox openings, instead of being level with them, as is usually the case; and the holes for the screws that hold the frames to the centre casting are countersunk, as projecting heads cannot be used, owing to the equalisers being close to the frames.

A piece of $\frac{3}{8}$-in. by 3/32-in. brass angle is riveted to each side of each axlebox opening, to serve as horn-cheeks; the side that goes next to the frame is filed away top and bottom to the shape shown. Use 3/32-in. charcoal-iron rivets if available; they don't work loose like copper rivets often do. The guard-irons can be cut from 3/32-in. steel and riveted in place whilst the frames are separate; leave them long enough, so that when the bogie is assembled, they can be bent to come over the railheads.

Bogie Centre

The bogie centre is a simple casting. As there is nothing projecting beyond the frames at either



Part cross-section of bogie

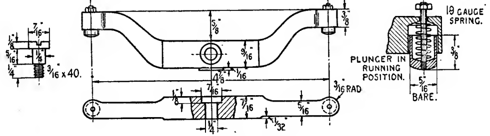
side, all you have to do is to smooth off the sides, either by milling or simply hand-filing. If you have a milling-machine, just catch the casting in the machine vice and run it under an ordinary side-and-face cutter. If a cutter over $\frac{5}{8}$ in. wide isn't available, use the widest you have, and take two or more "bites" without shifting the vertical adjustment of the table. The machine-vice on my horizontal milling-machine is a special type, with the movable jaw mounted just like the top-slide of a lathe, working over a flat slide with vee-edges and operated by a central screw. As type metal, perfectly parallel and of varying thicknesses; and its legitimate purpose is for spacing out printers' type when setting out headlines and so on. I bought the vice, which also has a swivel base fully graduated, just over ten years ago from Jones and Shipman, and it has served me well, saving a vast amount of time.

The sides of the casting can also be cleaned off by clamping under the slide-rest tool-holder and traversing across an end-mill or a home-made slot-drill or facing cutter held in the three-jaw; I have already described how to make these, and our "Duplex" friends have also dealt with the matter. A planer or shaper will also do the job; or the casting may be gripped in a four-jaw chuck, endwise, and the edges faced off with a round-nose tool set crosswise in the rest. If you do it that way, be careful not to take too greedy a cut, or the tool point will go west; beginners should always be mighty careful when facing anything, the cut of which isn't continuous. I've heard more than one tale of woe about the corner of a cylinder casting administering the K.O. to a carefully-ground tool, when a raw recruit started in to face off the flat surfaces.

The top and bottom of the casting can be faced-off by gripping in the four-jaw, and using a round-nose tool as above; the slot for the bogie-pin can either be end-milled out, or simply cleaned with a file, so that the bogie-pin slides easily from end to end. The distance between top and bottom of the casting should be slightly less than the length of the bogie-pin.

How to Erect Bogie Frames

Put the centre-casting between the frames, level with top of same, and put a cramp over the lot, to hold them temporarily together. Then lay them upside down on the lathe bed, or something equally flat, and line them up just like the main frames, putting two pieces of $\frac{1}{8}$-in. straight rod through the tie-bar holes, to make certain the



Bogie equaliser

this slide is quite true and parallel with the miller-table, work can be set truly by simply dropping it between the jaws and letting it rest on the slide; tighten up, and right away. If the work is too narrow to reach above the tops of the jaws, a piece of parallel packing is interposed between the work and the slide, and for this I use what our friends the printers call "furniture"; not the kind you need priority dockets for, though it certainly comes under the heading of "utility"! This furniture consists of pieces of frames are exactly opposite. Run the No. 30 drill through the screw-holes, making countersinks on the casting; follow with No. 40, and tap $\frac{1}{8}$ in. or 5-B.A., using countersunk screws when finally assembling.

An alternative way would be to make and fit the tie-bars first. For these, you need two pieces of $\frac{3}{16}$-in. round mild-steel, each $2\frac{3}{4}$ in. long. Chuck in three-jaw and turn down $\frac{5}{16}$ in. of each end to $\frac{1}{8}$ in. diameter, screwing $\frac{1}{8}$-in. or 5-B.A. Put these spigots through the end holes in the

frames, and nut them outside, using ordinary commercial nuts ; see plan illustration. This should bring the frames quite into line, and the proper distance apart, which is $2\frac{1}{4}$ in. ; so make quite certain that the tie-bars are just that distance between the shoulders before you start erecting. If all O.K., put the centre casting in place between the frames, level with top line ; hold temporarily with a cramp over the lot, and proceed to drill and tap for screws as above. Beginners shouldn't forget that on this bogie the horn-cheeks are *outside* the frame, contrary to those on the main frame.

Finally, on a line with the centre of the axlebox openings, and midway between them, drill a 5/32-in. hole through frame, well into the casting on each side ; tap this $\frac{3}{16}$ in. by 40, for the equaliser fulcrum-pins. Tighten up the screws well, and file off any burrs, so that the frames are perfectly smooth at each side.

Equalisers

Clean up the castings with a file ; centre-pop the middle of the thick part, and drill a $\frac{1}{4}$-in. hole clean through each, counter-boring to $\frac{1}{8}$ in. depth with a $\frac{7}{16}$-in. pin-drill. Tip for beginners : I never bother to make pin-drills of similar size, with different size pilots ; I just make one with a small pilot, say, $\frac{1}{8}$ in., and put a sleeve or bush over it for whatever other size may be needed, according to the diameter of the hole. In the present instance, all you want, to use the $\frac{1}{8}$-in. pilot in the $\frac{1}{4}$-in. hole, is a weeny bit of $\frac{1}{4}$-in. rod with a $\frac{1}{8}$-in. hole in it, slipped over the pilot ; time and trouble saved !

Next item is to centre-pop and drill the extremities, at $4\frac{7}{8}$-in. centres, as shown in the plan. Put a No. 50 drill clean through each, then open out with $\frac{5}{16}$-in. drill for $\frac{5}{16}$ in. depth (see small detail sketch). For the plungers, chuck a bit of $\frac{5}{16}$-in. steel rod, and if it won't slide easily in the holes in the ends of the equalisers, take a skim off, and teach it better manners. Face the end, centre and drill down $\frac{1}{4}$ in. depth with 15/64-in. or letter " C " drill ; part off at a full $\frac{3}{8}$ in. from the end. Ditto repeato until you have four plungers ; then reverse one in chuck, centre, drill No. 55, and tap $\frac{1}{16}$ in. or 10-B.A., and watch your step, because these little drills and taps break easily, and are comparatively expensive nowadays ! A drop of cutting oil on the tap works wonders. Slightly round the end—beginners can do that easiest with a file, whilst the lathe is running fast—then fit the pins, which are merely pieces of 16-gauge silver-steel or spoke-wire, about $\frac{3}{4}$ in. long, with a few threads of $\frac{1}{16}$-in. or 10-B.A. pitch on each end. Wind up a length of 19-gauge tinned steel spring wire over a bit of $\frac{1}{8}$-in. steel held in three-jaw (I have fully described spring-winding many times), snip off four bits about $\frac{1}{2}$ in. long, touch each end of each spring on your emery-wheel, and put them in the cups. The detail illustration shows the assembly ; if the nuts are not a good fit on the threads, give the end of the pin a slight tap with a hammer, to burr it a weeny bit, so that you don't lose the nuts on the road. The pins are merely " free passengers," their only function being to prevent the plungers falling out and getting lost when the equalisers are off the bogie, and retain them in place during erection. The plungers should have approximately $\frac{1}{4}$ in. of movement, the running position being halfway in, with the axleboxes in the middle of the openings, as shown in the assembly illustration.

The fulcrum-pins are turned up from $\frac{7}{16}$-in. round mild-steel held in three-jaw. Face the end, turn down $\frac{9}{16}$ in. length to $\frac{1}{4}$ in. diameter, further reduce $\frac{1}{4}$ in. of the end to $\frac{3}{16}$ in. diameter, and screw $\frac{3}{16}$ in. by 40. Part off to leave a head $\frac{1}{8}$ in. thick, and slot it with a hacksaw.

Axleboxes

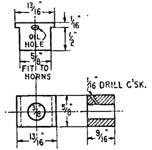
Our advertisers will probably supply a length of cast bronze rod for the axleboxes, and this can be dealt with exactly the same as described for the main axleboxes, either milling the rebate in a regular machine, or in the lathe, with an end-mill in the three-jaw and the work under the slide-rest tool-holder. Drill $\frac{1}{8}$-in. pilot holes through the boxes first, and " pair them off," same as main boxes, finally drilling $\frac{3}{8}$-in. clearing (letter " W " drill, if you have it), or if you have a $\frac{3}{8}$-in. expanding reamer, set it to cut a weeny bit oversize. Bogie axles should never be an exact fit, as the bogie twists about " all over the shop " on the kind of railway most little engines operate over ; and if they are too good a fit, they will bind, and the wheels will slide. Don't forget the oil-holes go on the flange side, so you can poke the spout of your oil feeder between the spokes of the wheels, and apply a drop of the needful where it can do good. Writing about that always reminds me of an amusing incident at Stourbridge which occurred whilst we were " evacueeing." I had just left a " port of call " on the gasoline cart, when I was hailed by a friend and fellow-conspirator coming in the opposite direction in another car. We both stopped and exchanged greetings, and when about to depart, my friend took a look underneath the front of my chariot. I said, " What's up—something coming adrift ? " He replied with a broad grin. " Oh, no ! I only wanted to see if you treated your king pins and steering joints same as you did the works of the old Brighton engines." He didn't catch old Curly out—I'm just as fond of an oil feeder now, as I was when " back in the days." The car may be short of petrol, but I'll see she never goes short of oil !

Wheels and Axles

Little need be added about these. One at least of our advertisers will be supplying the proper L.M.S. type wheel castings with triangular-section rims, same as big sister has. They are turned exactly as described for the coupled wheels, the bosses being reamed $\frac{5}{16}$ in. and the treads turned parallel or cylindrical, merely being slightly chamfered off, to avoid catching crossing frogs and bad rail joints. The axles are turned from $\frac{3}{8}$-in. round mild-steel held in three-jaw, if same is reasonably true, or else turned between centres, from steel of the next largest available size. Friends and relations of Inspector Meticulous may, if they so desire, drill a $\frac{1}{8}$-in. hole for a short distance in each end, to simulate the hollow axles of full-size practice, which are pretty conspicuous ; this may also be done to the coupled axles.

How to Assemble the Bogie

First, fit the equalisers to the side frames, and see that when the fulcrum-pins are screwed home as tightly as possible the equaliser is quite free to "see-saw" on the pin, yet without any side movement. Then put the axleboxes between the horn-cheeks, making sure that they are quite free to move up and down, and see that the plungers in the equalisers also work freely. Press one wheel on each axle, poke the axles through the



Bogie axlebox

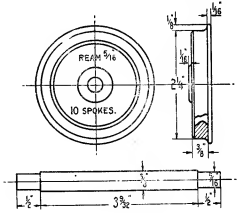
axleboxes and press on the other wheel, taking the same strict caution as before, when dealing with the coupled wheels, to prevent splitting of the bosses. The wheels, when right home, should run freely and without wobble.

When erecting the bogie on the main chassis, jam a bit of $\frac{1}{8}$-in. rod or wire under each box, between it and the bottom of the slot, to keep it in running position. Then put it on a flat surface, or a length of rail mounted on a flat board, and put the chassis over it, the bogie-pin entering the slot in the centre casting. When the coupled wheels are resting on the rail, or flat surface, the under-side of the bogie bolster should just touch the centre casting of the bogie; no rubbing washer is needed. When the large washer and nut are placed on the bogie-pin, and the nut screwed up tightly, the bogie should be quite free to move from side to side. If it doesn't, the bogie-pin is too short, but you needn't worry about that! Just make a thin washer the same diameter as the bogie-pin, with a $\frac{1}{4}$-in. hole in it, and slip it over the pin before putting on the big washer. That will pack out the nut a shade, and allow the necessary play.

Follow the "Words and Music!"

The next item will be the cylinders, and here I would like to say a reassuring word to those builders who are now on their first job. Rumours have reached me that certain club members have been advising first-timers—and others—not to fit the piston-valve cylinders which I am specifying, on the grounds that these require the use of elaborate grinding attachments, and so on and so forth. Fiddlesticks! Your humble servant, during the whole 24 years these notes have been running, has never knowingly "led anybody up the garden path" yet; and I have certainly no intention of doing so now. To make the piston-valve cylinders for "Doris," you need nothing more elaborate than your own lathe, an ordinary $\frac{5}{8}$-in. parallel reamer, and a modicum of what I should imagine everybody who builds locomotives possesses, viz. patience and common sense.

When I specified piston-valve cylinders for "P. V. Baker," I received many letters from prospective builders who were "afraid" of the piston valves, and wanted to use slide valves. I advised them all to stick to the "words and music," and up to the present, have had no complaints, nor tales of failure. Indeed, the examples of this engine that have operated on my own road, have put up most excellent performances. Personally, I've never had any trouble in all my own long experience, and the piston valves on fourteen-year-old "Fernanda" are as good now as when first fitted. Her sharp clear blasts, perfectly "separated" and distinct, even when running at high speed, were remarked on by the members of the North London S.M.E. who drove her on my road last November. The valves are simply bits of commercial ground rustless steel in ordinary reamed liners! The "secret," if you can call it such (I've broadcast it enough, goodness only knows!), is efficient lubrication. As long as there is a film of oil between bobbin and liner, the valves will remain



Bogie wheel and axle

steam-tight but not mechanically tight; and the lubricator I shall specify will look after that part of the business. 'Nuff sed!

For the Bookshelf

The "B.J." Photographic Almanac, 1948. (London: Henry Greenwood & Co., Ltd.) Price 5s., postage 6d.

Perhaps the greatest compliment one can pay this well-known annual publication is that little comment on it is necessary. As every amateur and professional photographer knows, it is an infallible guide to the most exact up-to-date information on the theory and practice of their craft, containing articles by well-known writers on current technical and artistic aspects of photography, useful formulae and data, and descriptions of the latest available apparatus. The usual art gallery of notable photographs of the year, reproduced in toned photogravure, is included in the contents.

The Water-Level

by H. H. Nicholls

THIS instrument does not appear to be well known, except to certain millwrights and fitters engaged on heavy machinery setting upon stone and concrete work, etc. But it would be very useful to set up a garden railway or a model car track, or to the man who wants to build a workshop or bungalow.

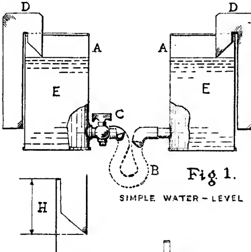


Fig. 1.

SIMPLE WATER-LEVEL

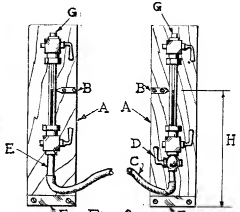


Fig. 2

When an engineer or surveyor wishes to set out a level line or to determine the difference of level between two objects, he uses an optical level and its "staff," held by an assistant.

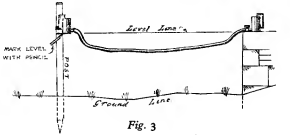


Fig. 3

For objects separated by distances of from about five to a hundred feet, however, a much cheaper and simpler appliance known as the "water-level" may be used.

In Fig. 1, a simple water-level is shown, made from two tins *A*,*A*, joined by a tube *B*, and having a cock *C* in the tube. *D*, *D*, are index fingers which hang upon the rims of the tins, so that the points touch the water *E*, *E*, which is best coloured or tinted.

The two index fingers *D*, *D*, are made exactly identical in respect of the height *H*. If one tin is higher than the other, file a notch in the tin so that both index points just touch the water when the two tins stand on a level plate, making sure that the tube *B* is entirely filled with water.

On removing one of the tins to another place, and slightly closing *C*, the water will rise or fall. Bring it to a position where it nearly touches the pointer, and open *C* fully. Then, with a little patience, the water can be brought to exactly agree with the pointer, when the bottom of the tin is exactly level with the bottom of the first tin. Hold the second tin against a post, and mark the position with a pencil (Fig. 3).

To work the instrument successfully, there must be no leakage from the connecting tube, and the cock must be well fitted to avoid any leak there. It will be found that when the two tins stand on a level plate, the water-level is best adjusted to the pointer, as shown, by adding a few drops at a time. *B* should be as large as possible.

A very superior water-level might be made by fitting two old water gauges from a scrapped steam boiler upon boards *A*, *A*, Fig. 2. The level is given by the pointers *B*, *B*. Connect the two gauges by a tube *C*.

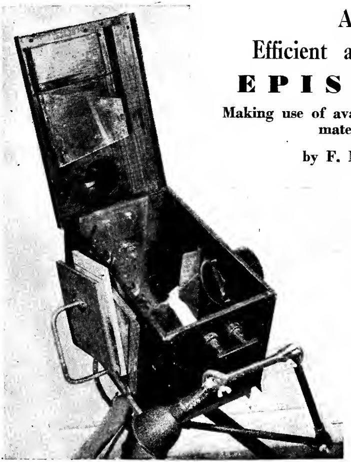
One only of the lower cocks need be used, as at *D*. The other one may be replaced by a plain connection *E*.

Plates *F*, *F* should be screwed to the bottoms of the boards.

The height *H* in this case is exactly equal on the two boards, measured from the pointers *B*, *B*.

If the gauges have plugs at *G*, *G*, these may be removed when the level is read or is to be filled. Otherwise, the cocks on the upper parts of the gauges must be opened.

The cocks at the back of the bottom fittings, where they are fixed to the boiler, are kept closed when the gauges are converted into a level.



An Efficient and Cheap EPISCOPE

Making use of available war surplus materials

by F. Mitchell

Close-up, showing a book held in place against the glass-covered picture aperture by the pressure plate. Also visible are the vertical and lid mirrors and polished aluminium reflector behind the lamp. Notice type and position of the handles and details of spot lamp

FOR those not familiar with the episcope, a few words on its nature, advantages and limitations are needed.

The episcope is a projector much used today in education as a visual aid, which has one great advantage over all other types of projectors, in that it is not, like them, dependent on a limited selection of films, film strips or slides. *Any* print or photograph in magazine or book or hand-drawn illustrations can be projected *in full colour* by this instrument, provided, of course, that the size of print is within the aperture size—in the one here described, 5 in. × 5 in.

As a teacher of art I have found it invaluable, enabling me to show clear, coloured enlargements, even up to 8 ft. × 8 ft. (in full darkness) from 5 in. × 5 in. prints, to thirty pupils at once. Normally a picture 40 in. × 40 in. is ample in size and extremely brilliant. In a recent issue of THE MODEL ENGINEER, "Jason" mentioned that he had an extensive selection of prints relating to ships which were available on loan to societies for lectures. This caused me to write these words, realising that the cheap efficient episcope, which I have made and fully tested, would be a splendid visual aid for club lectures on any subject, easily made by model engineers and easily operated by anyone.

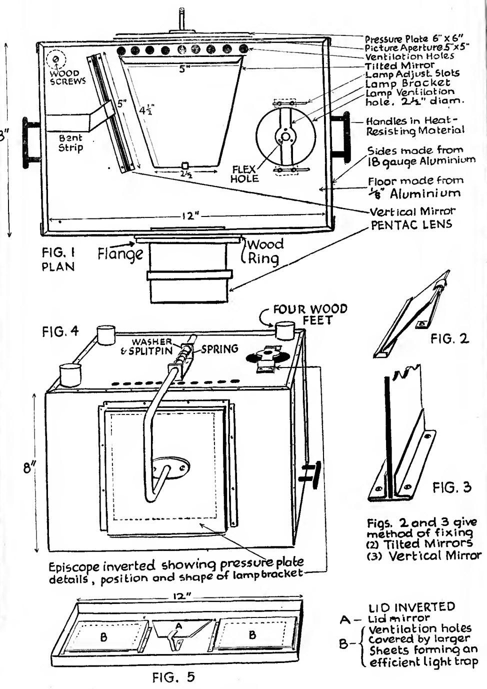
Materials Required

Sheet aluminium $\frac{1}{8}$ in. thick, 13 in. × 9 in. (for platform if desired), sheet aluminium about 18-gauge, 5 ft. × 1 ft., sheet aluminium, about $\frac{1}{8}$-in. thick, 12 in. × 8 in. (about £1); 1 class "A" projection lamp, 500 watt, 230 volt (about 30s.); 1 Edison screw-batten lamp holder (about 3s.); 1 piece of glass, 6 in. × 6 in. × $\frac{1}{8}$ in. (from an old picture); 3 mirrors, as indicated (about 4s.); 2 heat-resisting handles (2s. 6d.); 16 in. length of $\frac{5}{16}$-in. brass or steel rod; 1 Dallmeyer "Pentac" lens, 8-in. focus, f./2.9, ex-R.A.F. (£8 10s.); 1 ex-W.D. (signal lamp) tripod (14s. 6d.); 3 yd. strong electric cable, as used for electric fires (about 6s.); 1 switch and 1 adapter plug (5s.); 8- and 10-B.A. nuts and bolts (5s.); mat black paint (1s); 4 wooden feet, from thick dowelling (1s.).

It is essential that the centre of the lamp filament should be level with the centre of the lens, and that the lens-centre be level with and exactly opposite to the centre-point of the picture aperture. In other words, the three points mentioned must be at exactly the same level for best results.

Method of Making

The base should be cut to size, and $\frac{1}{2}$-in. ventilation holes, large lamp ventilating hole, and holes to receive 8-B.A. nuts (for securing the sides) drilled out. Next, the four side-members can be marked out for size, folding and



Sketches showing constructional details of the episcope

drilling, also the aperture for the lens in the front centre and the picture aperture in the back cut out. It will be noticed that the side plates overlap the base and each other with a generous 1 in. lap—this avoids light leaks.

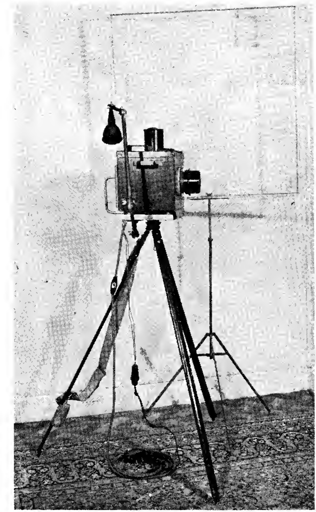
The Pressure Plate

The method I have employed for holding the print in place is, I think, unique. It is, as the picture and drawing (Fig. 4), shows, a simple spring-loaded affair, which is formed into a convenient handle (see Fig. 4). Only a light spring is needed to keep your picture in place. The chief advantage of this idea is that when the lecturer wants to use a picture contained in a thick and expensive book, and removal of the picture from the book is out of the question, the pressure plate can be swung down right out of the way and the book held against the aperture by hand.

The pressure plate is of wood, with a piece of black cloth glued on to the inside face. I think the fixing and design of the pressure-plate is clear from the drawing and photograph.

The lid can be a much simpler one than that on my episcope which has evolved into a rather complicated one as a result of a lot of experiment. To maintain ample *ventilation* I would advise that two rectangular apertures be cut in the lid each side of the mirror (see Fig. 5) thus, a stream of cooling air enters below the lamp and moves straight upwards through the lid. The simple light trap shown will prevent light leakage.

The purpose of the mirrors is, of course, to direct the light on to the picture aperture. There are three—two wedge shaped ones (the large one facing down from the lid at an angle, the smaller one fitted facing upwards on the floor) and a rectangular mirror $6\frac{1}{2}$ in. $\times$ 5 in. which stand vertically. These mirrors form a sort of three-sided box to concentrate the light upon the print and should be so placed that they just *cannot* be seen when one looks into the episcope from outside through the lens. Held lightly in position by bent aluminium strips and slides, each mirror must be "lined up" so that it is just on a line running from the periphery of the lens to the relative edge of the picture aperture; then keeping the edge nearest the lens still, swing the mirror carefully about until it is just out of sight when looking in through the lens. After marking the positions the mirrors can then be permanently fitted into place. The method of fitting is shown in Figs. 2 and 3 in the drawing.



A general view, showing episcope on tripod stand ready for use, and the portable screen frame

Handles and feet must be non-conductive because the lamp gives off considerable heat. Wood is quite suitable. A ring made from $\frac{1}{4}$-in. wood is desirable between the lens flange and the episcope front to insulate the lens from the heat.

The Light

It may occur to the reader that lighting from one 500 watt source only might be less satisfactory than two 250-watt lamps placed on each side of the print. Whilst it is true that two such lamps so placed do give a slightly more even light distribution, I have, after much experiment, decided in favour of the single 500-watt light

source. My reasons are: *First, expense*—these projection lamps cost about 30s whether 500 or 250 watt. To fit two 250-watt lamps would cost £3 after each normal life period as against only 30s. for your 500-watt lamp. *Second, efficiency*—the volume of light emitted by two 250-watt lamps is at least 25 per cent. *less* than that given out by one 500-watt lamp! *Third, heat.* The heat question is a tricky one to consider when designing this instrument. One is anxious, on the one hand, for absolute maximum light, but also anxious to keep down heat to a minimum to avoid possible adverse effect on the lens and curling the print. Two 250-watt lamps generate much more heat than one 500 watt and, as stated, they give less light.

The lampholder is supported in a bracket as shown in the drawing (Fig. 4) and adjustment of lamp position is possible by sliding the complete assembly in the slots after slackening the four securing bolts (see Fig. 1).

The Lens

This is a super efficient Dallmeyer "Pentac," 8-in. focus, f./2.9—R.A.F. surplus. They were fitted to the famous F.29 'plane camera, used for reconnaissance photography and are conveniently fitted with a flange (ask for this when ordering). A great amount of focus adjustment is not necessary. At a distance of 5 ft. 8 in. from the screen this lens throws a superbly brilliant and clear picture 40 in. × 40 in. from the 5 in. × 5 in. print. This is, I have found, a most suitable size, being large enough to be clearly seen by forty people in a normal classroom or lecture room. The normal price, by the way, of the "Pentac" is over £20, so at £8 10s. 9d. they are good value. These lenses are now even cheaper and plentiful, the complete camera is now being sold in Manchester for £5 5s.

The Screen

It should be understood that following normal laws of optics, the episcope reverses and inverts the picture. The inversion is corrected, of course, by placing your print in position upside-down, but this still leaves writing or printing running right to left instead of left to right. For straight pictures this does not matter very much, but there are two ways of getting over the difficulty. One way is to shoot the picture on to the screen *via* a mirror, this corrects the fault. The other way is to use a screen of translucent tracing paper and project from that side of the screen which is opposite to the audience. This is called back projection. Since for this purpose and for general convenience, an easily movable screen is desirable, I will describe the portable screen I have made from some scrap wood and an old music stand.

A strong, light frame 40 in. × 40 in. was made from some wood I had, 1¼ in. × ⅝ in. The adjustable rod which normally carries the actual music holder was taken from the music stand shouldered down to ¼ in. and threaded ¼ in. Whitworth. A ¼-in. hole was drilled into the middle of one of the four sides of the wooden frame and reinforced by a steel plate 4 in. × 1¼ in. × 3/32 in. To set up the screen the threaded rod is adjusted to the desired height in the music stand and then the frame is placed upon it, being held firmly in place by a wing-nut. Covered with draughtsmans tracing paper it is an excellent movable translucent screen with full height adjustment and is placed between the audience and the projector. To make it into a normal white screen a piece of white cloth or thick white paper is stretched on to the frame with drawing pins.

These are the important measurements:

The Lamp House, 12 in. wide, 8 in. high and 8 in. from back to front.

Mirrors

Bottom, wedge-shaped tilted mirror 5 in. × 4¼ in. × 2½ in.

Top, wedge-shaped mirror, 5 in. × 5 in. × 2½ in.

Vertical rectangular mirror, 5 in. × 6½ in. (upright).

Ventilation holes, a row of small ones, ½ in. diam. Large lamp vent, 2½ in. diam. (See Fig. 1.)

Two rectangular vents in the lid (see Fig. 5), 6½ in. × 2½ in.

The lamp filament is 5½ in. from the centre of the lens aperture and 5½ in. from the centre of the picture aperture.

The picture aperture glass is 6 in. × 6 in., giving a ½ in. overlap on the 5 in. × 5 in. aperture. It is held in position by an aluminium frame in four sections which are bolted to the lamphouse with 10-B.A. bolts. (See photograph.)

The pressure plate is 6 in. × 6 in. × ½ in. wood.

The arm is $\frac{5}{16}$ in. rod, 16 in. total length with an oval fixing plate silver-soldered to the end. The bracket carrying the rod is bent up from 3/32 in. × ⅞ in. strip bolted underneath the lamphouse floor. (See Fig. 4.)

The Tripod Stand and Platform

Whilst the episcope as described and shown in the drawings is complete in itself and can be operated from a table or similar base, I have found that a tripod stand, adjustable for height and angle is desirable. A war-surplus metal tripod designed to carry a signalling lamp is ideal for the job. These stands are amazingly strong, and to adapt them for our use is simple. An aluminium platform was made as shown in the picture and bolted to the removable bronze cap on the tripod. This platform is a simple affair bent up from ⅛-in. aluminium. The finished job has a 1-in. flap on each long side bent downwards at right-angles, whilst the two short sides have 1-in. flaps turned upwards. These flaps make the platform very rigid, whilst the upturned ones also serve to hold the episcope firm. A wooden platform would also serve the purpose. I went to the trouble of bushing the four wooden legs with brass bushes which were tapped out 6-B.A. Thus, by means of four bolts passing through the sides of the platform, the instrument is firmly secured to the platform and easily removable if necessary.

The Adjustable Spot Lamp

I found another war-surplus bargain in the spot lamp shown in the picture. Formerly a navigator's table lamp it is ball-jointed in four places and will remain in any desired position. By its 15-watt light the operator is able to select his next print, allowing him to switch off his projector lamp for a few moments to cool down the episcope and prolong the life of the lamp. As the picture shows, it is bolted beneath the platform.

Painting

The outside should be painted dull black to avoid reflection. The *inside* I find is best treated thus—the inside front surface (that around the lens) paint *white* to throw the light on to your picture. The back inside surface (around the picture aperture) *black*. The side nearest the lamp, don't paint but polish brightly to throw light over to your mirrors. The remaining upright inside surface, *black*. The floor and inside lid, *white*.

Operation

I would strongly advise that everything be set up and fully prepared before the lecture if possible. There is nothing more annoying and fatal than those last-minute unforeseen hitches. The lead turns out to be a yard too short, the plug doesn't fit the socket, all the windows but one can be blacked out easily, the table to hold the prints has to be passed unsteadily over the heads of the grinning audience, the prints are in anything but the right order for the talk, etc., etc. This kind of thing kills interest—your most valuable ally to a successful talk.

First, consider the relative positions of the projector, the screen and your audience. Remember that the episcope, unlike other projectors, is a "short throw" instrument which rules out the normal cinema arrangement of throwing the picture from the back of the audience over their heads on to the screen in front of them. In Fig. 6 I have indicated a practical arrangement which will ensure that all viewers can see the pictures with a normal white screen in use. Fig. 7 shows the somewhat simpler set out required when the translucent screen is used and the back projection method employed.

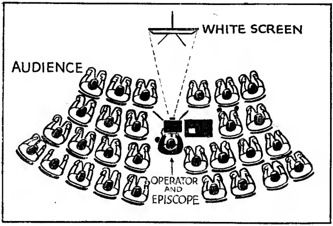


Fig. 6. Room arrangement for normal projection

Having set out your equipment and chairs and fixed the blackout, the next step is to adjust screen and projector so that the picture just fills the screen and is perfectly in focus. The best way to check on focus I have found is this. Most readers will probably know that a coloured print is composed of very tiny individual dots of colour which our imperfect eyes merge together. Well, when the projected enlargement on your screen is "dead on" and perfectly in focus, these magnified dots will be very clearly visible from about one foot away from the screen.

Finally, have your prints conveniently near you on the table, arranged carefully in the order in which you will need them. Switch off the projector lamp during each picture-change period to keep the episcope reasonably cool and to get most value from the lamp.

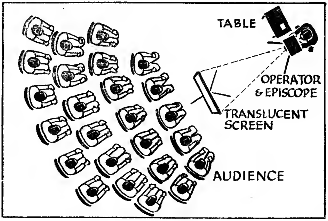


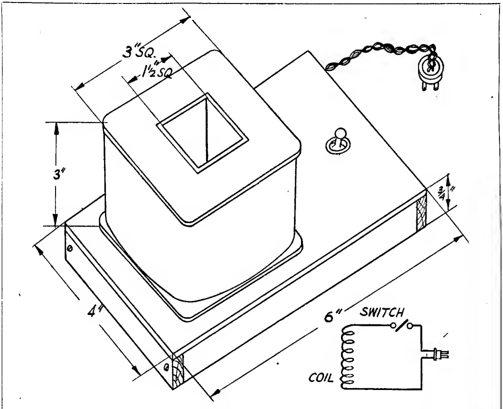
Fig. 7. Arrangement for back projection

I have used cinematograph, film-strip projector and slide projector and found none of these as generally useful and adaptable as the episcope.

A Demagnetiser for Small Tools

by John T. Rundell

A MAGNETISED screwdriver, or pair of pliers, is often very useful in the workshop, but there are occasions when they are an absolute nuisance, and some quick and simple method of demagnetising them would be welcomed. This is especially true in watch making or watch repairing, and however careful one is, these tools will persist in picking up bolts, springs, etc., just at the most awkward moments.



Isometric sketch of finished demagnetiser (not to scale), and the wiring diagram

The following paragraphs describe the construction, and methods of use, of a simple demagnetiser, which costs but a few shillings, and is run straight off the 200-240 volt a.c. mains. Apart from its conventional use as a demagnetiser, small articles can be magnetised with its aid in a few seconds, and thus a tool can be magnetised for a special job, and restored to its original condition immediately afterwards.

Construction

Basically, the instrument consists of a coil of wire, of physical dimensions suitable for the tools to be treated, and of electrical properties such that a suitable current is drawn from the mains and a satisfactory magnetic field is set up within the coil. The author has found that the dimensions given enable most jobs to be successfully tackled.

The bobbin is made first, from thin sheet bakelite or stout cardboard. Two end-cheeks, each 3 in. square, and with a 1½ in. square hole in them are glued on to a rectangular tube, also 3 in. long and 1½ in. square overall. When the glue has dried, a small hole is drilled in one cheek just clear of the centre tube, and one end of a reel of 30-s.w.g. enamelled copper wire passed through, as a lead-out. Then 6,000 turns are wound on (conveniently in the lathe), in about 30 layers of 200 turns per layer. Each layer is interleaved with thin paper, such as two thicknesses of good quality tissue. When all the wire is wound (about 2½ lb.), another small hole is made in the same cheek as before, to lead out the finish of the

(*Continued on page* 672)

Notes on Resonance Motors and Valves

by H. E. Fielden, M.I.Fuel

THESE notes on resonance jet motors are written to help anyone desiring to experiment in this direction, and whilst they contain nothing of a revolutionary nature they may give a certain amount of guidance. In the first place, extraordinary patience is required and it is almost certain that satisfactory results will not be obtained easily. The writer has been experimenting about three years with this and similar types of motors, and the results of many of these experiments have been more than disappointing. Secondly, a fair amount of accuracy is necessary in the actual carrying out of the work, but this, I am certain, should not unduly worry any model engineer interested.

the gases have left the nozzle a reduction of pressure to below that of atmospheric takes place in the chamber, and is assisted by the return pulse of the sound wave or wave of rarefaction, which is in harmonic frequency with the valve. The sound wave causes the valve to vibrate and lift, and as there is a partial vacuum existing, a fresh charge is drawn in. It is owing to this fact that a resonance motor will function whilst stationary, though the ram effect will be beneficial in most models, though not necessarily so. Once the motor is in action, the residual flame fires the incoming charges, thus causing continuity of running.

A resonance motor cannot function unless its

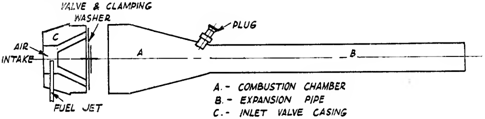


Fig. 1. Section through resonance motor

Before designing a resonance motor it is well to have a knowledge of the fundamentals and principles on which these motors operate. They are so simple to look at, but, believe me, that simplicity is very deceiving, and certainly ends with appearance. Referring to Fig. 1, we see that primarily the motor consists of a hollow combustion chamber joined to an expansion pipe. In the front of the combustion chamber is situated an inlet valve casing incorporating a spring-steel non-return flap valve which covers the fuel admission holes in the said casing. There is also some form of fuel supply and mixing chamber, and this can be fitted to the inlet casing. In addition to the above items, and for starting purposes only, a spark plug is screwed into the combustion chamber. It is so arranged that the spark plug is wired to the high tension lead of a continuously sparking coil similar to the old Ford T-type or a multi-cylinder magneto. A good fat spark for starting is essential.

The sequence of operations is as follows : a charge of petrol/air mixture is forced into the combustion chamber and is then fired by the spark plug, so giving rise to a rapid expansion of gases in the combustion chamber. Now this rapid expansion gives a resulting increase in pressure, which adds a further impulse or reinforcement to the standing sound wave. The expanding gases and the sound wave both travel to the nozzle opening and produce an increase in pressure at the opening. The reaction of the escaping gases provides the thrust, and the pressure due to the explosion holds the spring-steel flap valve tightly to the face of the inlet casing. After

effective length, i.e. length from valve to nozzle outlet, reinforces the frequency of the valve, and bearing this in mind, it is well to start off by designing the inlet valve and ascertaining its frequency. In the writer's case, experimental flaps were made of 0.005-in. spring steel and tested out against the middle C of a piano for pitch. If a middle C tuning fork is available, that will do, and we can make our valve to suit that frequency, which is in the neighbourhood of 260 vibrations or cycles per sec. It is well not to go much lower than this figure, otherwise the valve will be weak and the effective length of the motor may become too unwieldy. The frequency for any tone can be calculated quite simply, but a table is given showing the frequency for all the tones and half-tones for the octave commencing middle C upwards.

Note	Frequency	Note	Frequency
C	260 per sec.	G	391 per sec.
C (Sharp)	276 " "	G (Sharp)	414 " "
D	293 " "	A	439 " "
E (Flat)	310 " "	B (Flat)	465 " "
E	328 " "	B	492 " "
F	348 " "	C	522 " "
F (Sharp)	369 " "		

For ascertaining the frequency, a valve leaf should be cut and one end held firmly in a vice or cramp and the free end vibrated and held close to the ear. A distinctive note will be given and this has to be identified. It may be well to get the assistance of a friend who has a keen ear for "pitch" for this part of the job. But let us say our valve coincides with the note D ; we then know the frequency to be around 293 vibrations

per sec., as from the above table. From this data, then, the valve can be designed. It will be found that the thicker and shorter the valve leaf, the higher is the frequency and vice versa. A free flap of about ⅞ in. to 1 in. will probably be found sufficient.

diameter as the clamping washer. This can be removed if the valve is O.K. (See Fig. 2.)

The writer has found that five or six leaves to the valve are sufficient to synchronise, though a greater number would probably give better mixture distribution. The valve should be made

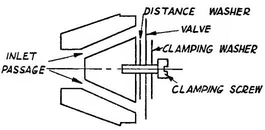


Fig. 2. Section through inlet casing

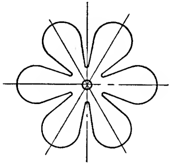


Fig. 3. Suggested shape of multi-leaf valve

Owing to considerations not mentioned, a multi-leaf valve will be necessary and the whole snag rests in making each leaf identical. This is rather a difficult operation, but it is no use proceeding further until each leaf gives the same tone with the valve firmly secured to the inlet housing in its working position. Difficulty will arise in carrying out this suggestion, as the valve will be damped, so it is recommended that a very thin smooth washer be inserted between the valve and face, being of exactly the same

from thin bright spring steel about 0.005 in. or 0.006 in. thick, and this material can be cut with snips or large scissors easily. Cut clean to form, as the edges cannot be filed. Clean off any burring around centre hole with oilstone—it is important that the valve be absolutely flat and smooth.

A resonance jet motor has been constructed, employing a valve made similarly as described, which functions very satisfactorily indeed and develops a considerable thrust.

A Demagnetiser for Small Tools

(*Continued from page* 670)

winding. The coil is finished off by binding with Empire tape, or bitumenised paper.

A suitable base is then made, similar to that shown in the sketch, and four holes are made in it, one for the switch (a miniature toggle switch), two for the leads to the coil, and one 1½ in. square, which coincides with that through the bobbin, and allows long articles to be dealt with. The two wires are then threaded through the holes in the baseboard and the coil glued into position. Finally, a length of flex is secured underneath with an insulated staple, and the wiring completed, as in the diagram.

Operation

The operation is very simple. Just plug into an electric point, switch on, and place the article to be demagnetised as far inside the coil as possible. Quite a strong pull will be felt, and the article should be withdrawn vertically to a height of about three feet from the coil. Switch off without allowing the demagnetised object to approach the coil again, and the job is done. Watch hair-springs and small articles, are treated similarly, being held in a pair of tweezers.

It was mentioned earlier that the instrument can also be used as a magnetiser, when the procedure is as follows: switch on; place the article inside the coil; switch off. The degree of magnetisation depends upon which part of the a.c. cycle was in progress at the instant of switching off, and one or two repeats may be necessary in order to "catch" the cycle at the proper point. However, this takes but a few seconds to carry out. Used in this way, the instrument is not, of course, satisfactory for remagnetising motor magnets, etc., it is only suitable for screw-drivers, knives, and the like.

Finally, two words of warning. Firstly the coil is only designed for intermittent use, and will get too hot if left on for longer than about five minutes at a time. The normal time of use is only a few seconds, however. Secondly, iron or steel articles left inside, with the current on, will warm up quite rapidly, apart from rattling noisily about, so don't leave odd nuts and screws in it.

★A Radio-Controlled Launch

by R. M. Cooper

THE speed control mechanism is similar to the cock for the auto-pilot, but instead of a spring return action the "Frog" motor drives the quadrant and pinion one way or the other by reverse connections on the auto-pilot selector switch.

In addition to this, the cock is constructed as a normal on-off cock, and is provided with screw adjustment stops to facilitate setting for tick-over and full speed. It is shown in Fig. 12.

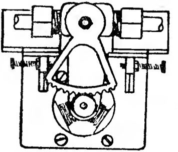


Fig. 12. *Speed control servo-mechanism*

Rudder Control

The rudder control "servo-motor" is perhaps, together with the auto-pilot, the most complicated o the "servo-mechanisms." (See Fig. 13.)

Fig. 14 shows its construction, and Fig. 15, the construction of its respective steam cock, the latter of which is again operated by a "Frog" motor and a quadrant and pinion, which is spring loaded to return to a centre position.

The operation of the cock is as follows:

1. Centre position — steam shut off.
2. Right position—steam fed to left cylinder, whilst exhausting right cylinder.
3. Left position—steam fed to right cylinder, whilst exhausting left cylinder.

The rudder steam motor consists of opposed cylinders, as shown, and these

* *Continued from page* 649, "*M.E.,*" *June* 17, 1948.

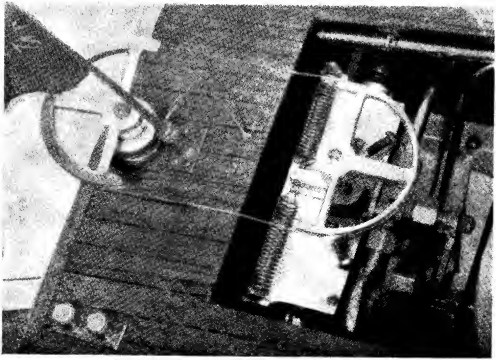


Fig. 13. *Close-up of the rudder servo-mechanism*

are coupled together by one common connecting rod on which is cut a geared rack.

A vertical shaft and pinion engages with this latter to drive the rudder post through a pair of cable quadrants located above the deck.

The bore is 1 in., this being decided on as it was not known how much energy was required to hold the rudder over at speed.

When the impulse is received by the radio, an increase in current occurs at the anode of the output valve, which chooses the relay contacts, switching on the auto-pilot cock motor, and sends the selector to a new position.

Let us say this position is to turn to starboard, so that we can analyse the operation for full and part turns.

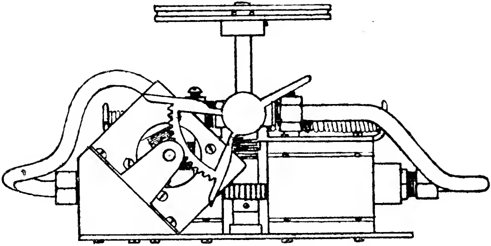


Fig. 14. Rudder steam servo-mechanism

It can now be stated that with 60 lb. of steam, ½ in. bore would be ample, and much less than this would do if an assisted rudder were used, though the rudder must not be fully assisted or balanced, as a certain amount of drag in the water slip-stream is required to help it to return quickly to zero when the steam is shut off.

The pistons are spring-loaded to return to centre, so that the boat can be operated on its stand out of the water, though the slip-stream does this function with better certainty.

All the mechanisms are mounted low in the boat, and are connected up to the boiler by piping, *via* a needle valve.

The cabin light does not need any explanation, and the method of connecting up is shown in Fig. 11.

Many other controls may be suggested, and it is easy to see that these could be included by increasing the number of switch positions on the auto-pilot selector switch.

The Total Equipment

The layout of the total equipment is shown in the block diagram in Fig. 1, and its disposition in boat in Fig. 2. Referring to Fig. 1 the operation is as follows :

The auto-pilot is sent round to position 1, after switching on transmitter and tuning in control receiver.

The operator can now send impulses by keying the transmitter, counting as he proceeds, and upon pausing one second on any of the positions, the respective servo goes into immediate operation.

Having now sent an impulse, we keep our finger on the transmitter key so as to prolong the signal and this allows the delay relay to function, which switches on the rudder cock motor.

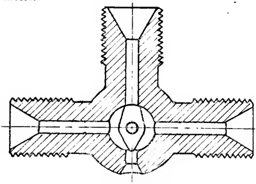


Fig. 15. Section through rudder servo steam cock

You will remember that this is spring-loaded to return to the off position, but so long as we prolong the signal, it will continue to turn thus allowing us to turn the amount required, and on removing one's finger from the transmitter, immediately sets the boat again on straight course.

In the case of fast and slow speeds, it is only necessary to prolong the signal until the boat responds, when the signal can be stopped—to continue it wastes current in the boat.

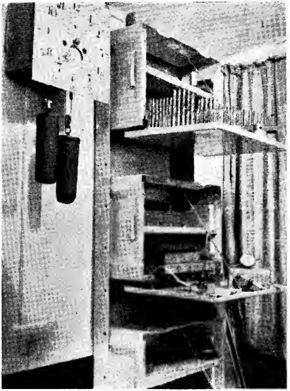
(Continued on next page)

A Cheap Set of Tool Lockers

by H.R.V.

WHEN re-planning my workshop I decided to dispense with the rows of tool racks which formerly I used to regard with so much pride, but were really a snare and a delusion in that they gave no protection whatever to small tools against rust and dirt. I decided that a set of lockers, although losing a certain amount of the accessibility of the racks, would more than make up for this deficiency by the added safety in storage.

Three steel boxes were purchased very cheaply from one of the many "surplus" merchants (*ex*-gunners will recognise them as 2-pounder ammo. boxes and the P.B.I. as mortar bomb boxes), the carrying handles were removed and



Tool lockers in the home workshop

they were bolted, one above the other, to two sections of Morrison shelter angle-iron. The whole assembly was secured to the workshop wall, inner shelves were fitted and with the addition of a length of steel chain to secure the lid in a horizontal position when hinged down, it can become a convenient platform on which to stand the tools while in use. Terry spring-clips can be added as required for such items as screwdrivers, although the lockers are really meant for the more delicate form of equipment.

When erected, the lockers were painted a pleasing shade of battleship grey and certainly looked more expensive than the 22s. which the whole set cost.

A Radio-Controlled Launch

(*Continued from previous page*)

It will be seen that current to operate the "servo-mechanisms" is only required in small pulses of negligible quantities, so that quite small batteries are used.

There are many possibilities with the above equipment, as it can be made for use with i.c. engines, provided a small compressor and storage tank are used.

The author is at present experimenting with a view to operating similar mechanisms with sparklet bottles, as used in soda syphons.

Care must be exercised in using these, as they are filled with gas at very high pressure (approximately 1,200 or 1,400 lb. per sq. in.), and they seem to have sufficient capacity to operate the mechanisms for reasonable periods.

Another method, when an i.c. engine is used, which shows promise, is a miniature boiler, as a large head of steam is not required, and this, fired by a gas burner with an aluminium high-pressure container, filled with butane gas from the Wee Dex gas cooker, would be suitable. The container could be 1/12th the capacity of the Wee Dex, which burns for 6 hr.